Polarization, Alignment, and Orientation in Atomic Collisions

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Synopsis The basic concepts and recent developments in the field of polarization, alignment, and orientation in atomic collisions will be discussed. Special emphasis will be placed on new experimental and computational techniques, some open questions, and outreach into areas beyond traditional atomic collisions.

Since the first edition of our book on Polarization, Alignment, and Orientation in Atomic Collisions [1], a number of significant developments took place regarding both the experimental studies of these phenomena and the theoretical treatment, especially concerning numerical calculations. Experimental developments include, for example, the magnetic angle changer [2] and the reaction microscope [3], as well as new experimental benchmark data that were obtained with these improved detection techniques.

Regarding the numerical treatment of the underlying collision processes, much progress has been made in developing convergent close-coupling techniques, either formulated in momentum space (CCC) [4] or in coordinate space using the R-matrix with pseudo-states (RMPS) [5, 6] approach. Furthermore, rapid advances in computational resources (hardware and software) have made explicitly time-dependent formulations [7] a competitive technique in many steady-state arrangements. Such approaches are, of course, necessary to describe short-pulse intense laser-matter interactions [8], where alignment and orientation studies have recently become possible as well (e.g. [9, 10]).

This presentation will start with an overview of the basic concepts, which will be followed by some examples of recent developments for electron, photon, and heavy-particle impact on atoms and molecules. Several open questions, including the validity of propensity rules as well as some surprising results for light polarizations after impact excitation by spin-polarized electrons, will be addressed. Finally, examples of how these concepts reach into fields beyond standard collision physics, e.g., applications in nuclear physics and the design of entangled quantum states, will be discussed. A second edition of [1] with many more details is currently in production.

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